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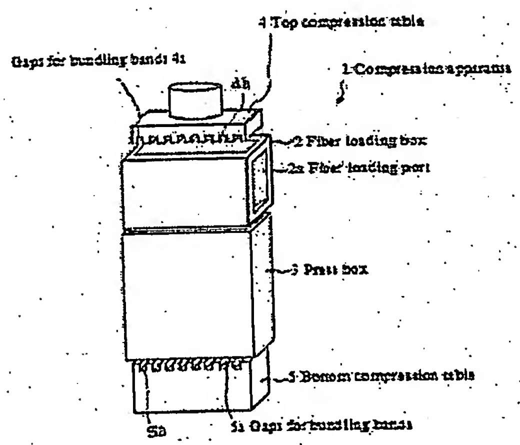
(54) [Title of the Invention] Apparatus for Compressing Articles to Be Packed in Bales, and Method for Compressing Same

(57) [Summary] (including amendments)

[Object] To provide a compression apparatus for stabilizing the compressed form of fiber masses, fiber tows, pulp, paper, and other articles that are cut to short lengths.

[Means of Achievement] The inner surface walls of a press box 3 of a compression apparatus 1 have tapered surfaces that have a taper angle of 2.0° or less and that gradually narrow toward the compression direction of the press jigs 4 and 5, and a covering layer whose coefficient of static friction with regard to the short fiber masses is 0.27 or less. It is thus possible to eliminate the large amounts of friction generated in regions between the short fiber masses being compressed and the inner surface walls of the press box, and a packed bale is obtained which has a stable compressed shape. Compression is performed with the lower portion of the short fiber masses configured so as to become gradually narrower in the compression direction of the press jigs; therefore, it will be possible for the packing shape to be maintained after packing so that all sides of the packed bale will be associated in a mutually perpendicular relationship, even if the lower portion of the compressed short fiber masses spreads out by the repulsion force (expansion force) of the short fiber masses. The packed bales can be properly stacked without any upward slanting, even if the packed bales are stacked in multiple tiers.



[Selected Drawing] FIG. 1

[Claims]

[Claim 1] An apparatus for compressing articles to be packed in bales, comprising:

a tubular press box having lateral inner walls; and

a pair of press jigs disposed in opposition and sandwiching said press box therebetween; and wherein short fibers or other such articles that have been loaded in said press box are compressed between said pair of press jigs and formed into a packed form;

said apparatus being characterized in that:

the inner surface walls of said press box have tapered surfaces that gradually narrow toward the compression direction of said press jigs.

[Claim 2] The compression apparatus according to Claim 1, characterized in that said tapered surfaces are formed in the height region of the articles when the compression in said press box is complete.

[Claim 3] The compression apparatus according to Claim 1 or 2, characterized in that the angle of the tapered surfaces is 2.0° or less.

[Claim 4] An apparatus for compressing articles to be packed in bales, comprising:

a tubular press box having lateral inner walls; and

a pair of press jigs disposed in opposition and sandwiching said press box therebetween; and wherein short fibers or other such articles that have been loaded in said press box are compressed between said pair of press jigs and formed into a packed form;

said apparatus being characterized in that:

the inner surface walls of said press box have a covering layer whose coefficient of static friction with regard to said article is 0.27 or less.

[Claim 5] The compression apparatus according to Claim 4, characterized in that said covering layer comprises a thin film body clad with a solid film lubricant.

[Claim 6] The compression apparatus according to Claims 4 or 5, characterized in that the inner surface walls of said press box have tapered surfaces that gradually narrow toward the compression direction of said press jigs.

[Claim 7] A method for compressing articles to be packed in bales wherein:

a tubular press box having lateral inner walls and a pair of press jigs disposed in opposition and sandwiching said press box therebetween are used to compress short fibers or

other such articles that have been loaded in said press box between said pair of press jigs and form same into a packed form;

said method for compressing articles to be packed in bales being characterized in that articles that have been loaded in said press box are compressed into a form that gradually narrows toward the compression direction.

[Claim 8] The compression method according to Claim 7, characterized in that said articles rub against the inner surface walls of said press box with a coefficient of static friction of 0.27 or less.

[Detailed Description of the Invention]

[0001]

[Technological Field of the Invention] The present invention relates to an apparatus for compressing articles to be packed in bales and a method for compressing same, wherein fiber masses, fiber tows, pulp, paper, and other articles that are cut to short lengths are compressed and formed into a prescribed packed form; and more particularly relates to an apparatus for compressing articles to be packed in bales and a method for compressing same, whereby articles can be stably compression-molded into the form of a good packed bale.

[0002]

[Prior Art] Using bale packing to pack fiber masses, fiber tows, pulp, paper, or other articles that are cut to short lengths into the necessary size has conventionally involved, first, loading the cut articles into a compression apparatus. In this compression apparatus, a compression plate (press jig) that can move up and down is provided to the side of one end face of a press box formed in the shape of a rectangular prism having openings on top and bottom, and a pressure receiving body (press jig) facing the compression plate is also provided to the side of the other end face of the press box. An upper side packaging sheet is attached to the compression plate, and a lower side packing sheet is attached to the pressure receiving body. The articles loaded in the press box are compressed between the compression plate and the pressure receiving body as the compression plate is moved along the inner surface walls of the press box, and the articles are formed into a substantially rectangularly packed form. After the press box has been withdrawn from between the pair of press jigs to the outside, the compression-molded articles are wrapped between the pair of press jigs by the upper and lower side packing sheets, and further wrapped

and packed by having bundling bands inserted into a plurality of bundling band gaps provided to the pair of press jigs, and the outer sides of the packing sheets bound with the bundling bands.

[0003] Of the six sides of this packed bale, the two upper and lower sides facing the pair of press jigs are of a size that is determined by the dimensions of the inner peripheral surface of the press box. The size of the remaining four sides is determined by the dimensions of the inner peripheral surface of the press box and the dimensions of the height according to the compression rate.

[0004] However, in order to reduce the size of the packed bales as much as possible to allow for increased transportation and shipping efficiency, the percentage to which the articles are compressed must be increased, and the bale must be packed in such a manner as not to be temporarily altered by the repulsion force (expansion force) of the articles. The articles are normally packed by being bound with a prescribed number of bundling bands so that the compression direction of the pair of press jigs is surrounded, with the articles being kept in a compressed state. If necessary, the bundling may be performed with a predetermined number of bands in such a manner that the bands intersect in a crossed shape.

[0005] In warehouses or other storage facilities, these packed bales are normally stored in rows and a plurality thereof are stacked on top of each other, with the sides having the largest areas being used as the situating face so that the profile in which they are stored will be stable. However, the repulsion force (expansion force) of the articles acts extremely forcefully on the top and bottom faces of packed bales whose dimensions are determined by the inner peripheral surface of the press box (sides facing the pair of press jigs); therefore, the regions protrude out from the top and bottom sides between the plurality of bundling bands that have been tightened so as to enclose the top and the bottom sides of the packed bale. Furthermore, the top and bottom surfaces of the packed bale form an irregular shape because of the bundling band gaps on the pair of press jigs. Therefore, if the top or bottom surface of the packed bale is used as the situating face, the profile of the packed bale will be unstable; accordingly, the side faces of the packed bale (sides that do not face the press jigs), whose size is determined solely on the dimensions of the inner peripheral surface of the press box and the dimensions of the height according to the degree of compression, have been used as the faces on which the articles will be situated.

[0006] Conversely, a plurality of packed bales can be transported simultaneously if the side faces of a plurality of bales that are lined up in a single horizontal row during storage are gripped

together. FIG. 7 shows a conventional example in which the packed bales are transported. FIG. 7 shows a topside view of the packed bales (with the surfaces facing the press jigs being the long sides 8a and short sides 8b of the packed bales 8 shown in FIG. 2). In this diagram, two packed bales 8, 8 lined up along the lengthwise direction, with the left and right sides of the bales simultaneously being gripped between platters 9 of the transport machine, are transported with the rectangular surfaces (consisting of the long side 8a and short side 8c of the packed bales 8 shown in FIG. 2) that do not face the press jigs (not shown) being used as the situating faces.

[0007]

[Problems to Be Solved by the Invention] When the plurality of conventional packed bales 8 are simultaneously gripped by the platters 9 of the transporting device for transport, the spacing over which the bales are gripped by the above-mentioned platters 9 will be (long side 8a of packed bales)×(number packed bales), as shown in FIG. 7. Problems are thus encountered; e.g., a limit is placed on the number of packed bales that can be transported at one time using the platters 9 of the transporting device having a prescribed spacing, and the transportation efficiency is severely reduced.

[0008] In order to resolve these inconveniences, a plurality of packed bales 8 are transported using the side faces of a rectangular shape with one side thereof being the long side 8a of the packed bale 8 (e.g., as shown in FIG. 6) as the faces gripped by the platters 9 of a transporting device; and the spacing at which the packed bale is gripped is (short side 8b of packed bale)×(number of packed bales). More packed bales can be transported at one time by the platters 9 of the transporting device as compared with the transportation example shown in FIG. 7. Therefore, the efficiency with which the packed bales 8 are transported can be improved.

[0009] However, when fibers or other articles are compressed in a conventional compression apparatus provided with a pair of press jigs disposed in opposition and the press box sandwiched therebetween, such as described above, a large amount of friction will be locally generated between the compressed articles and the inner surface walls of the press box when the article is compressed. As a result, a state is produced whereby an adequate compression force cannot be applied all the way to the lower portion of the press box because of the friction generated when the articles are compressed. In this state, if the packing operation is performed as described above, the articles will be packaged with an uneven density distribution in the packed bale, and

over time the shape of the packed bale will inevitably change into a substantially four-sided truncated cone with a bottom face that is wider than the top face.

[0010] A problem is thus presented in that if a plurality of bales are simultaneously gripped by the platters of the transport machine with the side faces of the packed bales arranged in a single horizontal line, and an attempt is made subsequently to transport the bales in a single action, it will be impossible for the side faces of the plurality of packed bales to be gripped in parallel, so that the plurality of packed bales will bow outward from between the platters and assume an extremely unstable profile.

[0011] Also, packed bales compressed by a conventional compression apparatus assume a shape, as described above, wherein the bottom face side is wider than the top face side, with the side faces of the packed bale being slanted. Therefore, even if the packed bales are stacked a plurality of levels high on their side surfaces, it will be impossible for them to be stacked in a directly perpendicular manner relative to the situating surface. A problem is thus presented in that a gradual upward slant will develop, and the profile in which the packed bales are stacked will be extremely unstable.

[0012] Therefore, the tasks involved in storing, transporting, and shipping the packed bales are themselves problematic, require a certain level of safety to be simultaneously maintained, and are also highly labor-intensive. As a result, the tasks of storing, transporting, and shipping the packed bales require a commensurate amount of time to be spent and great care to be taken. Such circumstances have led to a demand for a packed bale configuration that enables transport thereof to be performed in a more efficient manner.

[0013] The present invention resolves the problems with the prior art, with it being an object thereof to provide an apparatus for compressing articles to be packed in bales, which stabilizes the form in which are compressed fiber masses, fiber tows, pulp, paper, or other articles that are cut to short lengths, so that the tasks of storing, transporting, and shipping the packed bales can be efficiently performed. It is a further object to provide method for compressing articles to be packed in bales enabling short fibers or other articles to be stably compression-molded into a satisfactory bale configuration.

[0014]

[Means Used to Solve the Above-Mentioned Problems] The invention according to Claim 1 is an apparatus for compressing articles to be packed in bales, which is provided with a tubular

press box having lateral inner walls and a pair of press jigs disposed in opposition and sandwiching the press box therebetween, and with which fiber masses or other such articles that have been loaded in the press box are compression-molded between the pair of press jigs into a packed form; the apparatus being characterized in that the inner surface walls of the press box have tapered surfaces that gradually narrow in the compression direction of the press jigs.

[0015] Even in the apparatus for compressing articles to be packed in bales according to Claim 1 of the present invention, at least one of the press jigs is advanceably and retractably disposed within the tubular press box having lateral inner surface walls, as with conventional practice. Fiber masses, fiber tows, pulp, paper, or other articles that are cut to short lengths (hereinafter referred to as "short fiber masses") are loaded between the pair of press jigs, and the short fiber masses are then compacted to a prescribed shape between the pair of press jigs. The compressed short fiber masses are covered with a packing material, and further bundled with a bundling material.

[0016] The inner surface walls of the press box of the compression apparatus of the present invention have tapered surfaces that gradually narrow toward the compression direction of the press jigs. Specifically, a space is maintained in the inner surface walls of the press box of the compression apparatus of the present invention, wherein the short fiber masses are compressed in a configuration so that they gradually become narrower towards the compression direction of the press jigs.

[0017] In the present invention, for example, the lower portion of the short fiber masses are compressed in a form that gradually narrows towards the compression direction of the press jigs. Even if the lower portion of the compressed short fiber masses spreads out by the repulsion force (expansion force) of the short fiber masses, it will be possible for the packing shape to be maintained after packing so that all the sides of the packed bale will be associated in a mutually perpendicular relationship, and the resulting packed bale will have a stabilized compressed form. Surfaces of the packed bale other than those that face the press jigs can therefore be selected as the face on which the bale is to be set. The packed bales can be properly stacked without an upward slant, and the tasks involved in the storage, transportation, and shipping of the packed bales can also be readily performed. A plurality of packed bales is thus able to be stably positioned, and the man-hours required for the tasks involved in the storage, transportation, and shipping of the packed bales can be considerably reduced.

[0018] The position of the tapered surfaces and the taper angle should be set at such an interval so that no contact is made with the press jigs. There are no particular limitations on the position in which the tapered surfaces are formed and the taper angle; however, it is particularly advantageous if the tapered surfaces are formed in the region of the article height when the compression in the press box is complete, as with the invention according to Claim 2, whereby the above-mentioned effect will be assuredly exhibited.

[0019] The invention according to Claim 4 is an apparatus for compressing articles to be packed in bales, which is provided with a tubular press box having lateral inner walls and a pair of press jigs disposed in opposition and sandwiching the press box therebetween; the apparatus being characterized in that fiber masses or other such articles that have been loaded in the press box are compressed between the pair of press jigs and formed into a packed form; and the inner surface walls of the press box have a covering layer whose coefficient of static friction with regard to the short fiber masses is 0.27 or less.

[0020] A covering layer is formed on the inner surface walls of the press box and has a coefficient of static friction with regard to the short fiber masses of 0.27 or less. Examples of materials from which this covering layer can be constructed include ultrahigh molecular weight polyethylene; titanium, aluminum, titanium carbide, or other ceramics; and solid film lubricants. This covering layer can be formed using a well-known cover-forming method that has conventionally been in widespread use.

[0021] According to these configurations, the inner surface walls of the press box are imparted with slipperiness, with the coefficient of the friction relative to the short fiber masses able to be dramatically reduced on a continuous basis. It is thus possible to eliminate the large amounts of friction generated in regions between the short fiber masses being compressed and the inner surface walls of the press box, and a packed bale having a stabilized compressed form can be effectively obtained.

[0022] The invention according to Claim 5 is characterized in that the covering layer has a thin film body covered with a solid film lubricant. A solid film lubricant is particularly employed efficaciously as the covering layer. Examples of solid film lubricants include conventional well-known molybdenum disulfide solid film lubricants and fluororesin solid film lubricants. Thin film bodies that are smooth and of uniform dimensions can be efficaciously formed on the inner

surface walls of the press box using a well-known film-forming method that has conventionally been in widespread use.

[0023] It is possible to prevent abnormal wear between the inner surface walls of the press box and the short fiber masses because the thin film body has a low coefficient friction and also has excellent resistance to wear. The initial compression force in relation to the short fiber masses is maintained, and the compression of the short fiber masses can be stabilized to a substantial degree because the force of friction between the short fiber masses and the inner surface walls of the press box does not dramatically fluctuate.

[0024] The invention according to Claim 6 is characterized in that the inner surface walls of the press box have tapered surfaces that gradually narrow toward the compression direction of the press jigs. In order for dramatic results to be obtained from the actions and/or effects of Claim 1, tapered surfaces formed on the inner surface walls of the press box become gradually narrower toward the compression direction of the press jigs, with it also possible to form a covering layer whose coefficient of static friction with regard to the short fiber masses is 0.27 or less. According to these configurations, the force of pressure to which the short fiber masses are subjected can be made uniform, and uniform compression can be accomplished. Furthermore, the short fiber masses can be molded into a form that gradually narrows toward the compression direction of the press jigs.

[0025] The invention according to Claim 7 is a method for compressing bale packaging articles, wherein a tubular press box having lateral inner walls and a pair of press jigs disposed in opposition and sandwiching the press box therebetween are used to compress short fibers or other such articles that have been loaded in the press box between the pair of press jigs, and form same into a packed form; and this method for compressing articles to be packed in bales is characterized in that articles that have been loaded in the press box are compressed into a form that gradually narrows toward the compression direction.

The compression method of the present invention is carried out using the compression apparatus described in Claims 1 through 6. The invention according to Claim 7 represents a typical method thereof, and, using the tapered surfaces formed on the inner surface walls of the press box, the short fiber masses are assuredly compressed into a form that narrows toward the compression direction, according to the compression dimensions based on the compression ratio between the press jigs.

[0026] In order for the articles to become gradually narrower in the compression direction, compression-molding can be performed using the tapered surfaces formed on the inner surface walls of the press box; e.g., as described above, or using a device provided with a protruding part which slants towards the compression plate from the peripheral edge of the pressure-receiving plate facing the compression plate. The pressure applied to the short fiber masses as generated by the compression from the press jigs allows the molding of short fiber masses wherein the pressure-receiving plate side narrows relative thereto. As a result, the effect of the invention described in the claims is definitively achieved, and the short fiber masses are able to be kept in a stable configuration.

[0027] The above-described actions and/or effects are exhibited to a high degree; therefore, the causing of articles to rub against the inner surface walls of the press box at a coefficient of static friction of 0.27 or less as with the invention pertaining to Claim 8, enables abnormal wear between the short fiber masses and the inner surface walls of the press box to be prevented, and the desired packed configuration to be effectively obtained. Furthermore, as with the above-mentioned inventions, a good packed form can be maintained for long periods of time, even during storage, transportation, and shipping.

[0028]

[Embodiments of the Invention] A suitable embodiment of the invention will be described in detail below using the attached drawings.

FIG. 1 is a schematic diagram showing an example of an apparatus for compressing articles to be packed in bales as a typical embodiment of the present invention. FIG. 2 is a schematic diagram showing press jigs used in the same compression apparatus and a packed bale. FIG. 3 is a plan view of a press box used in the same compression apparatus. FIG. 4 is a longitudinal cross-section view of the same press box. The present embodiment is described using a packed bale of fiber masses, fiber tows, or other fibers that are cut to short lengths (hereinafter referred to as "short fiber masses") by way of example; however, the embodiment is not limited thereto. For example, the embodiment can be used for a variety of articles obtained by compressing pulp, paper, or other articles that are cut to short lengths and molding them into the predetermined packed form.

[0029] The compression packing apparatus (not shown) is mainly composed of a scale hopper, a transporting apparatus, and a compression apparatus. In a compression packing apparatus of this

type, the fibers that are cut to short lengths are stored in advance in the scale hopper (not shown). The short fiber masses are then fed in a prescribed amount into the compression apparatus via the transporting apparatus. As shown in FIG. 1, the compression apparatus 1 of the present embodiment is provided with a rectangular fiber loading box 2 having a fiber loading port 2a with communicating upper and lower openings; a rectangular press box 3 opening upwardly and downwardly and disposed in mutual opposition to a bottom side of the loading box 2; and a top compression table 4 and a bottom compression table 5, which are a pair of upper and lower press jigs, arranged in mutual opposition with the boxes 2 and 3 therebetween.

[0030] The fiber loading box 2 is fixed to moving means (not shown). The press box 3 is moveably attached to the moving means, independently of the fiber loading box 2, with at least one side thereof being openable and closeable, as shown in FIG. 3. According to the example shown in the drawings, an opening/closing door 3a is provided to one side wall of the press box 3 via a hinge or the like. The top compression table 4 is attached to compression means (not shown) that moves in a downward direction to compress the short fiber masses. The bottom compression table 5 is fixed to supporting means (not shown).

[0031] In the present embodiment, as with a conventional apparatus, a prescribed amount of the short fiber masses in the scale hopper (not shown) is loaded from the fiber loading port 2a of the fiber loading box 2 into the press box 3 via a conveyor belt, plunger, or other transport apparatus. The short fiber masses are compressed in the press box 3 between the top compression table 4, to which an upper side packaging sheet is attached, and the bottom compression table 4, to which a lower side packaging sheet is attached. This compression operation can be performed only once, or it can be repeated two times or more, in order for the necessary amount of short fiber masses to be compressed to a prescribed compression height.

[0032] After the short fiber masses have been compressed, the openable door 3a of the press box 3 is opened, and the press box 3 is either moved in a lateral direction by the moving means, or both compression tables 4 and 5 are moved in a lateral direction by the moving means with the short fiber masses sandwiched therebetween. The short fiber masses are then removed and re-compressed between the compression tables 4 and 5. The short fiber masses are then wrapped, by machine or by hand, with the packaging sheets 6, composed of an upper side packaging sheet attached to the top compression table 4 and a lower side packaging sheet attached to the bottom compression table 5, as described in the foregoing. After the short fiber masses are wrapped,

bundling bands 7 are inserted into the plurality of bundling band gaps 4a, 5a provided to the compression tables 4, 5, and the fiber masses are packed. A short rectangular packed bale 8 is thereby produced, as shown in FIG. 2.

[0033] The compression apparatus 1 described above can be constructed of a main compression apparatus (not shown) and a plurality of preliminary compression apparatuses. In such instances, preliminary compression is performed in the press box 3, whereupon the press box 3 is moved to the compression apparatus via moving means (not shown), and the short fiber masses are formed to a prescribed compression height under the main compression. Moving means with which the press box is removed downward or upward and separated from the short fiber masses may be used instead of moving means with which, once the openable door 3a of the press box 3 has been opened, the short fiber masses gripped between the compression tables 4, 5 are moved in a horizontal direction.

[0034] The compression packing apparatus and associated compression apparatus 1 constructed as described above have a structure that is well-known and has conventionally been in widespread use. Therefore, the present invention is not limited to the above-described configuration. The structure of the press box 3 used in the compression apparatus 1 is the main configuration of the present invention. The structure of the press box 3 can be employed in a variety of compression packing apparatuses that perform compression, wrapping, and packing. There are no particular limitations as to the shape of the inner surface walls 31 of the press box 3 of the example shown in the drawings; however, according to the present embodiment, it is particularly advantageous for the inner dimensions of the press box 3 to have a long side L1 of 1080 mm and a short side L2 of 680 mm, as shown in FIG. 3. Setting these [lengths] as the inner dimensions enables the packed bales 8 to be efficiently transported in existing containers.

[0035] As shown in FIG. 4, the inner surface walls 31 of the press box 3 have tapered surfaces 32 that gradually narrow in the compression direction of the top compression table 4 in order to suppress the lower portion of the fiber masses from expanding considerably more than the upper portion of the fiber masses when the fiber masses are packed. According to the present embodiment, it is preferable for the taper angle of the tapered surfaces 32 to be 2.0° or less, and inside the press box 3 is ensured a formation space A within which the short fiber masses are compression-molded into a form that gradually narrows in the compression direction of the top

compression table 4. It is further preferable and particularly advantageous for the tapered surfaces 32 to have a taper angle of 0.5° or greater to 2.0° or less.

[0036] In the present invention, the established position of the tapered surfaces 32 should be set on at least one of the opposing pairs of inner surface walls 3, in a position that does not come in contact with the top compression table 4. The present invention is not limited to the example shown in the drawings. According to the present embodiment, the tapered surfaces 32 are formed toward the lower part of the pair of inner surface walls 31, 31 that are opposed along a horizontally long lengthwise direction, over a region H of the height of the articles when compression is completed in the press box 3. In the present invention, it shall be apparent that the tapered surfaces 32 can be formed in at least a portion of the region H of the height of the articles.

[0037] According to the aforedescribed configuration, the short fiber masses can be assuredly compressed in the inner surface walls 31 of the press box 3 according to the compression dimensions between the top compression table 4 and the bottom compression table 5. The pressing force acting on the short fiber masses as generated by the compressive pressure of the top compression table 4 enables the short fiber masses to be molded so that the bottom compression table 5 side is narrower in relation to the top compression table 4 side. When the short fiber masses are packed, a shape is formed, e.g., wherein the lower portion of the short fiber masses gradually narrows toward the compression direction of the top compression table 4. Accordingly, even if the lower portion of the compressed short fiber masses spreads out as a result of the repulsion force (expansion force) of the short fiber masses, it will be possible for the packing shape to be maintained after packing so that all the sides of the packed bale will be associated in a mutually perpendicular relationship, and the resulting packed bale will have a stabilized compressed shape.

[0038] Furthermore, in the present embodiment, the inner surface walls of the press box are imparted with slipperiness, with the coefficient of the friction between the inner surface walls 31 of the press box 3 and short fiber masses being dramatically reduced on a continuous basis. The inner surface walls 31 of the press box 3 have a covering layer whose coefficient of static friction with regard to the short fiber masses is 0.27 or less. A covering layer that is smooth and has even dimensions may be efficaciously formed on the inner surface walls 31 of the press box 3 using a well-known covering (film) molding method that has conventionally been in widespread use.

[0039] Ultrahigh molecular weight polyethylene; or titanium, aluminum, titanium carbide, or other ceramic can be employed as the material of the covering layer. This covering layer can also be constructed from a thin film body covered with a solid film lubricant having a low coefficient of friction and excellent resistance to wear. Examples of solid film lubricants that can be employed include conventionally known generic Teflon, silicon, molybdenum disulfide solid film lubricants, and fluororesin solid film lubricants.

[0040] If the covering layer is formed on the inner surface walls 31 of the press box 3, the large amount of local friction generated between the short fiber masses and the inner surface walls 31 of the press box 3 when the short fiber masses are compressed will be eliminated, and abnormal wear can be prevented. The friction between the inner surface walls 31 of the press box 3 and the short fiber masses will not vary in regions, and the compression of the short fiber masses can be stabilized from the initial compression force acting on the short fiber masses.

[0041] There are no particular limitations as to the position in which the covering layer is established on the inner surface walls 31 of the press box 3; however, in the present embodiment, a covering layer (not shown) having a coefficient of static friction with regard to the short fiber masses of 0.27 or less is formed on the entire surface of the inner surface walls 31 of the press box 3. This configuration allows the pressing force acting on the short fiber masses to be equalized, uniform compression to be achieved, and the short fiber masses to be formed in a configuration so as to gradually become narrower toward the compression direction of the top compression table 4.

[0042] It shall be apparent that the present invention is not limited to the above-mentioned embodiments. In the present embodiment, for example, there are no particular limitations as to the weight of the packed bale 8; however, it is preferable that [the weight] be 200 kg or greater or 600 kg or less. There are no particular limitations in the present invention as to the ideal fiber to be compressed and packed, provided that the fiber is a commonly used one; however, the present invention is particularly advantageous when used to compression-pack fibers that have a strong repulsion force; especially acrylic fibers. It is also preferable for the density of the packed bales 8 to be 300 kg/m^3 or greater. If the density of the packed bales 8 is less than 300 kg/m^3, the packed bales 8 will have an unstable profile when stacked during storage, which is not suitable for practical application.

[0043] A plurality of compression cycles are performed at a low compressive pressure (e.g., approximately 400 kPa) acting on the [short] fiber masses in the press box 3. The short fiber masses are preferably repeatedly compressed so that the intended packing volume is achieved. It is possible to use a variety of apparatuses and methods with which the short fiber masses may be compacted to the intended packing size; however, the compressive pressure in the compression apparatus 1 is preferably 9 MPa or less.

[0044] Furthermore, according to the above-described embodiment, a compression apparatus 1 is illustrated, wherein the bottom compression table 5 is fixed, and the short fiber masses are compressed by the top compression table 4 moving in a downward direction. However, the present invention is not limited to this example. The top compression table 4 may be fixed, and the bottom compression table 5 may move in an upward direction. Alternately, the top compression table 4 and the bottom compression table 5 may both advance and retract.

[0045] In the above-described embodiment, an example is given in which a horizontally wide packed bale is compressed; however the present invention is not limited to this example; e.g., as shown in FIG. 5, it shall be apparent that the present invention may be used for the compression of vertically long packed bales. In either instance, the gradual narrowing of the articles in the compression direction as accomplished using the tapered surfaces formed on the inner surface walls of the press box may instead be accomplished by performing compression-molding in a configuration, e.g., with a protruding part slanting from at least one of the opposite peripheral parts of the bottom compression table 5 toward the top compression table 4, as described above.

[0046] Furthermore, there are no particular limitations regarding the materials used for the above-mentioned packaging sheets 6, provided that the form of the packed bale 8 is preserved; however, e.g., a polypropylene fabric with a polypropylene sheet laminated on either or both of its surfaces can be efficaciously used. There are no particular limitations in regards to the material, size, quantity, or other attributes of the bundling bands 7, provided that the form of the packed bale 8 is preserved. It is preferable that the material be appropriately selected so that the length of the bands while the packed bales 8 are in storage or after they have been shipped will not exceed 300 mm relative to the length of the band at the time of bundling. In the present embodiment, the bundling bands 7 are composed of a polyester material.

[0047] The compression apparatus 1 pertaining to the present embodiment configured as described above can stably yield packed bales 8 in a six-sided packed form wherein all surfaces

thereof are in a mutually perpendicular relationship; it is therefore possible to ensure an adequate level of safety when the packed bales 8 are stored, transported, and shipped. Faces of the packed bales 8 other than those facing the press jigs can therefore also be arbitrarily selected as the face on which the bale is to be situated, and the packed bales 8 can be properly stacked a plurality of levels high for storage.

[0048] FIG. 6 shows a transportation example wherein the situating face is one that consists of a side 8b of a packed bale 8 corresponding to the short side L2 of the press box 3, and a side 8c of the packed bale 8 corresponding to the compression height. The symbol 9 represents the arm parts (platters) of a transporting device. As shown in FIG. 3, the packed bales 8 shown in FIG. 6 have sides 8a, 8b (1120 mm and 720 mm), which correspond respectively to the long side L1 and short side L2 of the press box 3; and a side 8c (1100 mm), which corresponds to the compression height. When a plurality of packed bales 8 are simultaneously gripped by the platters 9, the maximum grip spacing is 2240 mm.

[0049] As can be seen in FIGS. 6 and 7, only two bales can be gripped when the face used as the situating face consists of sides 8a and 8c of a packed bale 8, as with conventional practice. Therefore, the number of packed bales able to be transported at one time is inevitably limited, and transportation efficiency is dramatically reduced. Conversely, as described above in the present embodiment, the short fiber masses can be maintained in a consistently stabilized shape, and faces of the packed bales 8 other than those facing the press jigs can also be arbitrarily selected as the situating face. Therefore, if sides 8b and 8c of a packed bale 8 are established as the situating face, three bales will be able to be gripped by the platters 9. As a result, the packed bales 8 can be readily stored, transported, and shipped; and the man-hours needed to store, transport, and ship the packed bales 8 can be considerably reduced.

[0050] Further specific working examples of the present invention, as well as comparative examples, will be described below. The methods used to measure and/or evaluate the characteristics and other attributes were as follows:

[0051]

(1) Coefficient of static friction

A plate (1000 mm×2000 mm) of the same material used for the inner surface (cladding) material of the press box 3 was placed so that the top surface thereof was horizontal. A 300 kg packed bale 8 of fiber from which the 720 mm×1050 mm lower packing sheet 6 had been

removed was then placed on the plate. After having been left to stand for one minute, the packed bale 8 was pulled horizontally. The force applied when the packed bale 8 was moved was measured by a force gauge, and the coefficient of static friction was calculated using the following equation (1):

$$\mu s = Fs/Fp \qquad (1)$$

μs: coefficient of static friction

Fs: static friction force (N)

Fp: contact force (N)

[0052]

(2) Fineness

The method described in section 8-5-1A of JIS L-1015 was followed to measure the mass of 300 strands of fiber cut to 30 mm, according to which the corrected fineness was calculated. The fineness was determined as the average of five cycles of measurement.

[0053]

(3) Crimp number

The method described in section 8-12-1 of JIS L-1015 was followed to count the number of crimps over a span of 25 mm when an initial load of 0.18 mN × the displayed Tex number was applied to a single fiber strand, with the average of twenty counts being used as the crimp number.

[0054]

(4) Shape stability of packed bales 8

The faces on which the packed bale 8 was situated were packed bale 8 side 8b, which corresponds to the short side L2 of the press box 3; and packed bale 8 side 8c, which corresponds to the compression height. The packed bales 8 were stacked in four tiers, whereupon macroscopic evaluations were made and judgments awarded by five people. A passing result (⊙) was awarded if all five people deemed that the packed bales 8 did not slant in their stacked profile, and the packed bales had excellent shape stability. A passing result (○) was also awarded if the bales had good stability. All other results were considered unacceptable (×). Below is a comparison of instances where the press box 3 of the present invention was used and instances where a conventional press box was used.

[0055]

(Working Example 1)

An acrylonitrile copolymer (acrylonitrile/vinyl acetate=93/7 (weight ratio)) with a reduced viscosity of 1.95 was obtained by an aqueous suspension polymerization method. The resulting copolymer was dissolved in dimethylacetamide so that the copolymer concentration was 25 wt%, yielding a raw spinning solution. This raw spinning solution was then wet spun at 40°C in a spinning bath filled with an aqueous solution of 30 wt% methylacetamide. Drawing to five times was carried out while the solvent was washed in boiling water. An oil was applied, and drying/compacting was then performed at 150°C by a heat roller. A relaxation heat treatment was performed using steam pressurized at 250 KPaG, yielding an acrylic fiber bundle having a single yarn fineness of 3.3 dtex, and a fiber bundle fineness of 150 ktex.

[0056] 11 crimps were again formed in the acrylic fiber bundle every 25 mm, whereupon the bundle was cut to a length of 102 mm. 300 kg of the raw stock was weighed out, and then loaded into the press box 3, which had inner dimensions of 1080 mm × 680 mm and inner surface walls 31 covered with a solid film lubricant. The fiber was compressed ten times at a compression pressure of 400 kPa using the top compression table 4, which was 1060 mm × 660 mm in size. The press box 3 containing the mass of short acrylic fibers was moved down to the bottom compression table 5, and the short fiber masses were once again compressed between the top compression table 4 and the bottom compression table 5 at a pressure of 2.0 MPa. The openable door 3a of the press box 3 was then opened, and the press box 3 was returned to its original starting position. The short fiber masses were once again compressed between the top compression table 4 and the bottom compression table 5 at a pressure of 2.7 MPa. As described above, the short fiber masses were then wrapped with wrapping sheets 6, which had been laminated with a polypropylene sheet, and [the exterior thereof] was strapped with bundling bands 7 composed of a polyester material, resulting in a 300 kg packed bale 8. Measurements were made of the coefficient of static friction relative to the inner surface material of the press box 3 and the short fiber masses, and evaluations were made of the shape stability of the packed bale 8. The results are shown in Table 1.

[0057]

(Working Examples 2 through 5, Comparative Example 1)

A 300 kg packed bale 8 was obtained according to the same method used in Working Example 1, except that variations were made in the fineness of the fiber, the cut length, the inner surface material of the press box 3, and the taper angle. Measurements were taken of the coefficient of static friction of the inner surface material of the press box 3 and the acrylic fiber, and evaluations were made of the shape stability of the packed bale 8. The results thereof are shown in Table 1.

[0058]

[Table 1]

	Fineness (dtex)	Cut length (mm)	Material used for inner surface of press box	Taper angle	Coefficient of static friction	Stability evaluation
Working Example 1	3.3	102	Ultrahigh molecular weight polyethylene	none	0.23	⊙
Working Example 2	11	102	Fluororesin solid film lubricant	none	0.18	⊙
Working Example 3	5.6	76	Ultrahigh molecular weight polyethylene	1°	0.22	⊙
Working Example 4	1.0	32	Fluororesin solid film lubricant	2°	0.20	⊙
Working Example 5	9.0	102	SUS304 (#300 finish)	2°	0.28	○
Comparative Example 1	3.3	76	SUS304 (#300 finish)	none	0.29	×

[Brief Description of the Drawings]

[Figure 1] Schematic diagram showing an example of an apparatus for compressing articles to be packed in bales as a typical embodiment of the present invention.

[Figure 2] Schematic diagram showing examples of the press jigs and a packed bale used in the same compression apparatus.

[Figure 3] Plan view of the press box used in the above compression apparatus.

[Figure 4] Longitudinal cross-section view of the above press box.

[Figure 5] Diagram showing another example of a packed bale formed by the above compression apparatus.

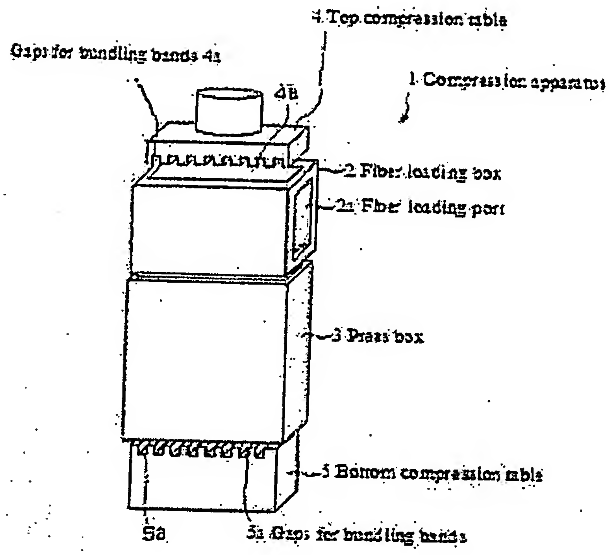
[Figure 6] Diagram used to describe an example wherein a packed bale formed by the same compression apparatus is transported.

[Figure 7] Diagram used to describe an example wherein a conventional packed bale is transported.

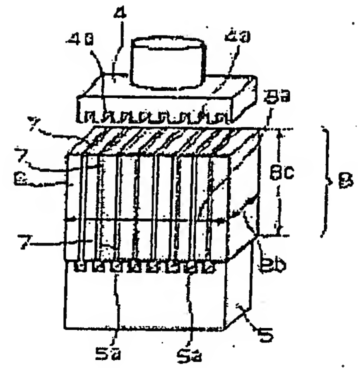
[Key]

1:	Compression apparatus
2:	Fiber loading box
2a:	Fiber loading port
3:	Press box
3a:	Openable door
4:	Top compression table
4a, 5a:	Gaps for bundling bands
5:	Bottom compression table
6:	Packaging sheets
7:	Bundling bands
8:	Packed bale
8a-8c:	Side of packed bale
9:	Platters of a transporting device
31:	Inner surface wall
32:	Tapered surface
A:	Molding space
H:	Region of article height
L1:	Long side of press box
L2:	Short side of press box

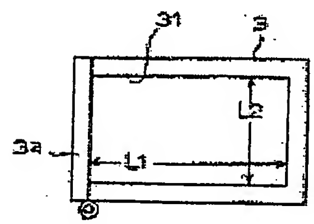
[Figure 1]



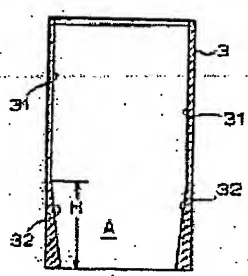
[Figure 2]



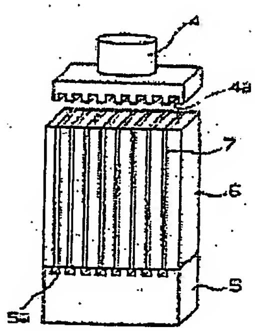
[Figure 3]



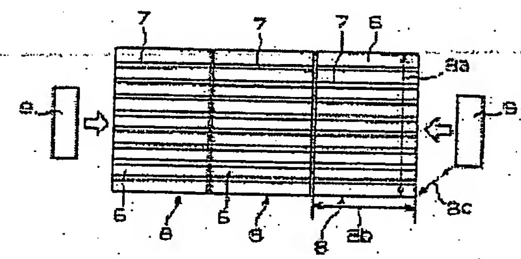
[Figure 4]



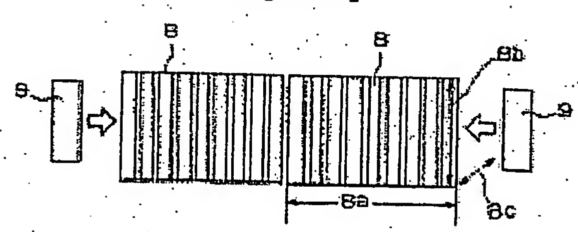
[Figure 5]



[Figure 6]



[Figure 7]



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